

GC-FR-3207-002

FINAL PROJECT REPORT
OF
STOLS® GEOPHYSICAL MAPPING
OF
295 ACRE WOODS AND
ADDITIONAL 5.5 ACRE WOODS
AT JEFFERSON PROVING GROUND
MADISON, INDIANA

Prepared for:

US ARMY ENGINEERING & SUPPORT CENTER, HUNTSVILLE
ATTN: CEHNC-OE-DC/MR. GLENN EARHART
POB 1600, HUNTSVILLE, AL 35807-4301

Purchase Order No. DACA87-98-F-0068
GSA Schedule No.: GS-35F-5176H

Prepared by:

Alan Crandall, STOLS® Project Manager
GEO-CENTERS, INC.
7 Wells Avenue
Newton, MA. 02459

August 1999

GEOPHYSICAL MAPPING
Of
THE 295 ACRE WOOD and ADDITIONAL 5.5 ACRE WOOD
At
JEFFERSON PROVING GROUNDS
MADISON, INDIANA

1.0 Scope

1.1 This report documents the geophysical mapping project that was used to statistically characterize Unexploded Ordnance (UXO) at the 295 acre wood and an additional 5.5 acre wood at Jefferson Proving Ground, - Madison, Indiana. The report documents the two sites, the geophysical mapping equipment, the new approach to statistical site characterization used that required no site gridding and no brush or tree clearing, the data processing and analysis performed on the acquired geophysical data, the statistical and final selection of representative targets to be investigated, and the anomaly reacquisition and marking results. The purpose of the project was to geophysically map at least nine (9) miles, or about 3.6 acres, of the two wooded sites at Jefferson Proving Ground (JPG), to statistically characterize potential UXO that may exist at these two sites. A man-portable array of two magnetometers with a swath of 1 meter and an integrated Differential Global Positioning System (DGPS) chosen for its reported performance under tree canopy, was used to geophysically map the pseudo-random survey paths. The same DGPS was used to reacquire and mark the final selected targets.

2.0 Executive Summary

2.1 This project demonstrated that it is possible to geophysically map wooded areas for potential UXO contamination with available DGPS. The project required no site gridding or tree/brush clearance. GEO-CENTERS' Portable Surface Towed Ordnance Locator System (Portable STOLS®), with a newly integrated rover GPS receiver, successfully completed the geophysically mapping of the 295 acre wood and an additional 5.5 acre wood at Jefferson Proving Ground, Madison, Indiana. The mapping was conducted during the week of 7 to 11 September 1998, with full leaf canopy. A pseudo-random survey was conducted to statistically characterize each site using sets of survey lines that were approximately parallel (pseudo) and that followed the path of least resistance (random) through the woods. Portable STOLS®, configured with the DGPS rover receiver performed extremely well, faithfully mapping the geophysical data through the woods. The system operated well with both a local differential base station and a US Coast Guard differential base station. The final selected targets were reacquired, using the same DGPS equipment, and marked from 8 through 11 May 1999, again with full leaf canopy.

2.2 Portable STOLS® deployed two total field cesium vapor magnetometers mounted 0.5 meters apart on a composite frame. The rover GPS antenna was mounted directly above the right magnetometer. A backpack hosted an embedded computer and custom sensor interface which sampled each magnetometer at 20 HZ and the rover GPS receiver that output position locations every second. The operator stood in the middle of the "L" shaped frame, with shoulder straps attached to the backpack and the magnetometers 1.5 meters in front of them.

2.3 A professional land surveyor established two Differential GPS base station locations to provide position control for this project. These base stations were selected to provided real time differential GPS corrections to the geophysical mapping (rover) positioning system (see APPENDIX A for details). Additionally, differential corrections broadcast by the US Coast Guard along the Ohio River were successfully used through the wood canopy. The availability of U.S Coast Guard differential GPS corrections, currently available along all navigable waterways, greatly simplified mapping logistics by not requiring a local base station to provide accurate position control.

2.4 .A reference magnetometer was set up in the vicinity of the JPG12 control point location, established for this project. This station measured and logged the earth's changing background magnetic field strength every 15 seconds (0.067 Hz) during the course of the geophysical survey. This background data was subsequently subtracted from the survey data to remove the effects of diurnal shifts/changes and to normalize the data around a zero value.

2.5 To verify that Portable STOLS® was performing properly, a local prove-out plot was established near the JPG12 monument. A single East/West line, 100 feet long, was established and checked with a handheld gradiometer for background objects. Portable STOLS® was also used to establish a background file before the placement of test targets. Three sections of pipe were used as prove-out targets and were placed on the surface (as directed by CEHNC on 4 September 1998) along the prove-out plot as follows:

Pipe 1: 1.25 inch diameter x 24 inches long, at 25 foot mark, oriented N/S

Pipe 2: 2.00 inch diameter x 8 inches long, at 50 foot mark, oriented N/S

Pipe 3: 1.25 inch diameter x 24 inches long, at 75 foot mark, oriented E/W

2.6 Portable STOLS® was then used to acquire data over the prove-out plot. The data was processed and imaged in the same manner as the survey data. A visual evaluation of the proveout data showed all three targets were detectable and that the system was operating as designed. Image maps of the prove-out background and targets are included in APPENDIX B. Note that the "magnetic shadow" of the STOLS® tractor-trailer is evident on the east end of the prove-out lane.

GEO-CENTERS, INC.

The analysis of the prove-out targets resulted in the following:

Target Report / Dig Sheet for JPG Woods, Prove-out plot					NAD83, Indiana East, meters
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments
1	118402.46	398575.73	0.0	s	Test target 1
2	118409.97	398574.81	0.1	s	Test target 2
3	118417.39	398573.98	0.3	s	Test target 3 - in trailer shadow

2.7 A set of 14 survey lines was acquired in the 295-acre wood with total area coverage of 3.36 acres, or about 8.45 miles of area sampled. The additional 5.5-acre wood was surveyed with a set of 7 lines, providing 0.51 acres covered, or about 1.28 miles covered. The total length of geophysical mapping was 9.73 miles (9.0 miles required) with a total area of 3.87 acres sampled. A traverse map, that shows the position data of the pseudo-random paths walked, is included with this report in APPENDIX C.

2.8 Magnetic anomalies, consistent with unexploded ordnance (UXO) with a diameter greater than or equal to 40 mm and a depth (to the top of the object) less than 8 feet, were identified and selected (61 targets in the 295 acre wood and 28 targets in the additional 5.5 acre wood). The complete target report/dig sheet is included as APPENDIX D and lists a unique target number, Easting (m), Northing (m), depth estimate (m), size estimate (s, m, 1, p), and optional analyst's comments. A random selection of 31.5 % (29) of the reported 89 targets was required and is provided as the Statistical Selection of Representative Anomalies in APPENDIX E.

2.9 The Corps of Engineers (COE) decided to reacquire all 89 reported targets instead of the randomly selected 31.5% of the targets. But because the actual survey area of the 295 acre site was extended west to the base perimeter road, 29 of the reported 89 targets were west of the original 295-acre site boundary. Therefore, COE reduced the GEO-CENTERS' target list from 89 targets to 60 and added 29 targets that were selected by the COE. The final selected target dig-sheet is included as APPENDIX F.

2.10 All 89 of the final selected targets were reacquired, verified, and marked for investigation/disposal from 8 through 11 May 1999 in accordance with the approved work plan. If a reacquired target could not be verified with a hand held magnetic gradiometer, it was reported as Not Verified (NV). If the reacquired and verified position was different than the reacquired location, the offset and direction were recorded. A separate contractor investigated each marked target and recorded what was found, providing the target ground truth. The final results, including offset and ground truth are included in the final dig-sheet in APPENDIX G.

GEO-CENTERS, INC.

2.11 Seventy (70) of the eighty-nine (89) reacquired targets produced contacts. One 60 mm fuze mortar was located. A piece of a 4.5 inch rocket was found. All other contacts were scrap. Twenty (20) of the eighty-nine reacquired (89) targets were not verified. Nineteen (19; 6 from GEO-CENTERS' target selections and 13 from COE's target selections) of these twenty (20), not verified targets, produced no contact at the marked location. One of the not verified targets did produce a target.

3.0 Site Descriptions

3.1 Site 1 - 295-Acre Woods

3.1.1 This site is roughly triangular and lies just west of the old base airfield. Woodfill Road bounds it on the north. Tokyo Road forms the eastern boundary. Tokyo Road joins the West Perimeter Road at the south end of the site, with the Perimeter Road defining the western boundary of the site. An active, though low use, railroad track runs east/west through the site. The site is covered, except the far south end, by mature woods with a 40 to 50 foot canopy. The undergrowth is thick with vines, briars, and brush, but walkable routes through the site were found.

3.2 Site 2 - Additional 5.5 Acre Woods

3.2.1 This is a rectangular area just northeast of the 295-acre woods. Woodfill Road defines its southern boundary. A clear dirt lane extends north from Tokyo Road and defines the site's western boundary. An unused railroad track runs east/west through this site. From the map provided, the site dimensions are roughly 600 feet east/west by 400 feet north/south. These dimensions were measured and marked/flagged at the southeast, northeast, and northwest corners. This site is also covered with mature woods with a 40 to 50 foot canopy. The underbrush was more severe at this site, making walking more difficult.

4.0 Equipment Description

4.1 Portable STOLS© is a magnetometer-based geophysical survey system which rapidly acquires high-density magnetic data over areas of interest and produces same-day image maps of the magnetic fields of buried unexploded ordnance (UXO), underground storage tanks, pipes, containers such as drums, and other subsurface ferrous objects. The system is configured with arrays of cesium vapor total field magnetometers (model 822A) on half-meter spacing. The portable system can host a maximum of 4 magnetometers in a gradiometric; two over two configuration on an "L" shaped composite frame. For this survey, the standard two side by side magnetometers on half-meter centers were deployed. The Portable STOLS® data acquisition

system, embedded in an aluminum backpack, samples each magnetometer at 20 HZ. A standalone reference magnetometer (model 856) was deployed to log the diurnal variations of the earth's magnetic field every 15 seconds. This data is used to reference correct all survey data.

4.2 STOLS® utilizes data from a differential global positioning system (DGPS) which locates every data point acquired with a relative point to point precision of 10 to 20 centimeters and a sub-meter accuracy in any subsequently located target. The distances of these locations are relative to a base navigation station that is set up prior to surveying. For this survey, a professional land surveyor determined the coordinates of the local base station used. A US Coast Guard base station was also used when the system's differential radio link failed. All subsequent location information is calculated relative to these base station locations. With each base station surveyed to benchmark accuracy, all locations can then be calculated off this benchmark into any standard coordinate system (e.g., UTM, State Plane, etc.). A new rover DGPS receiver was used for this survey for its increased performance under tree canopy. The unit was a Trimble model Pro XR with an L1 antenna and "built-in" US Coast Guard Differential radio. This receiver was set up as a "code only" receiver, which enabled it to maintain lock on available satellites more robustly than receivers that attempt to maintain phase lock on the GPS carrier signals. A DGPS position was logged every second.

4.3 On-site data processing combines the sensor data and the satellite positioning data and creates data images of the surveyed area. Surface objects (e.g. the two survey control monuments) can be surveyed with the DGPS to create a data set of landmarks that can be overlaid on the data image to correlate the data with known, site-specific features. The result is a visual output indicating areas in which buried objects or utilities are located, as well as areas that are clear for further excavation/use. Daily output image maps show site coverage, as well as any missed areas not covered by a sensor. These maps are viewed in gray scale or pseudo color. Post analysis outputs include preprocessed data in a variety of Geographical Information System (GIS) compatible formats and a target report/dig sheet in hard copy and in electronic ASCII format. All raw data and selected processed data are archived daily to tape for permanent storage and future consultation. Target reports list unique target number, target location, likely size and depth, along with optional operator comments.

4.4 Anomaly reacquisition (Waypointing) uses the same DGPS system to relocate and flag suspected UXO target locations for investigation/disposal. Coordinates from the selected target report/dig sheet are entered into the rover DGPS receiver, which provides guidance information to rapidly relocate targets of interest. Once the reported position is relocated and flagged, a handheld gradiometer is used to verify the presence of the target and to refine its location, if necessary. Any relocation offset is logged on the target report/dig sheet, the marking flag is repositioned, and the ground is painted with high visibility paint.

5.1 The technique used for this survey was a "pseudo-random walk" over the site ("pseudo" because the site was covered with a set of roughly parallel lines; "random" because the team followed the path of least resistance through the wooded areas). Lines were planned to be roughly 110 meters apart. The lead man provided UXO avoidance support as well as maintaining the rough E/W track heading while selecting the best path through the woods. The second in line was the Portable STOLS® operator acquiring the geophysical and position data. The third in line was the support team member carrying spare batteries, drinking fluids, and other support equipment. The last person was also responsible for maintaining rough track heading.

5.2 The survey began in the NW corner of the 295-acre wood (the intersection of the West Perimeter Road and Woodfill Road) and followed the tree line along Woodfill road, west to east, until the road angled SE. There the survey entered the woods. This line maintained a SE heading all the way to the railroad tracks running through the site and never did return to the planned E/W heading. The next line was parallel to Woodfill Road, about 10 meters into the woods. It began just south of the access road to the northern control point, where the STOLS® tractor-trailer and data processing station was located. Position data at the east end of this line were not usable, so the geophysical data were terminated at the last point of usable position data. The third line started south along Tokyo Road and headed west to the Perimeter Road. Line four began farther south along the Perimeter Road and headed east to Tokyo Road.

5.3 Two east/west lines were attempted along both sides of the railroad tracks. These lines proved to be the most difficult to walk and did not provide any usable position data. The survey was then moved to the southern end, with each new line moving north.

5.4 Line five was the southern-most and shortest line in this site. Lines six through thirteen moved north about 100 meters each. Line fourteen, the last line, was moved about 200 meters north to split the gap in the area sampled. This last line brought the total area sampled just over the required 8 miles (a total area coverage of 3.36 acres or about 8.45 miles of area sampled).

5.5 The survey then moved to the additional 5.5-Acre site that is located just northeast of the 295-acre site. The bounds of this additional area were roughly established using Woodfill Road as the southern boundary, and an old north/south lane across from Tokyo Road as the western boundary. The eastern and northern boundaries were scaled from the site map and marked with flags. This area was sampled with a set of 7 east/west lines.

5.6 The first line began in the SW corner and followed Woodfill Road along the tree line. The second line began about 50 feet (15 meters) north and headed west. This site was very difficult to walk due to dense vines. The third line moved north to the next favorable point of entrance into

the woods and crossed the second line in several places. During the next two lines, the position data degraded to a useless point and a stop was required. The survey continued at the next favorable satellite coverage window. Four additional east/west lines were acquired, each moving north about 50 feet (15 meters). The seven useful lines in this site brought the area coverage to 0.51 acres, or about 1.28 miles sampled.

6.0 Data Processing and Analysis

6.1 Survey data and reference magnetometer data are transferred to the on-site workstation. From the position data, the site boundaries were determined. The navigation data are then examined and corrected for jumps that are not humanly possible. These jumps come from two primary sources:

1. Loss of differential link. This throws the rover receiver into non-differential (autonomous) mode that has markedly less accuracy. If the loss of differential link is short (1 to 5 seconds), the "out of place" points are forced back in line with the neighboring valid positions. If the loss of differential link continues for a long time, a pause is added to the last valid position point and data are deleted until the next valid position point. This leaves a gap in the sampled data.
2. Lock on less than four (4) satellites. This condition causes the rover receiver to output the last valid position for a short time, and then to quit reporting positions altogether, until lock on four or more satellites is reacquired. This manifests itself as clusters of position fixes at an old position and then a jump to the next valid position. If the jump is small, and the path/course of the survey is predictable, the old position and the next valid position can be connected, and the magnetometer data linearly interpolated between them. If the jump is too great (loss of satellites for a long time) and the survey path/course can not be reliably predicted, a pause is added to the line at the last old position and commenced at the next valid position point. This leaves a gap in the sampled data.

The navigationally corrected data are then stored as preprocessed data.

6.2 Next, the data are diurnally corrected with reference magnetometer data and interpolated onto a 10-cm grid for visual display and operator Quality Assessment (QA) and Quality Control (QC). Several programs can be run to "clean up" the data. These include inter-magnetometer offset corrections (sensor to sensor calibration - not typically used), directional magnetometer bias corrections (directionally sensitive system noise - typically applied to vehicular STOL® data), reference magnetometer offset correction (reference magnetometer reporting a fixed geological offset from survey data), and "bad magnetometer value" corrections. Bad

magnetometer values manifest themselves as black (blue) or white (red) squares in the interpolated image. They can simply be stripped from the data, or run through a median filter. The cause of these "bad magnetometer values" has several sources, including a failed or intermittent sensor, or a misaligned sensor. All cesium vapor magnetometers have active and dead zones, which interact with the direction of the local magnetic field. As the sensor alignment moves from an active zone into a dead zone, magnetometer values that are within the sensor's dynamic range but clearly incorrect are reported. If a significant number of valid, but "bad" magnetometer values are observed in the interpolated image, the data are run through a median filter (currently set with a 15 point window and a ± 250 gamma threshold) where outlying magnetometer values are replaced with the window average. This survey required the median filter to be run on all data files. This is due to the nature of the sensor **and the** site conditions experienced. Whenever the array became entangled in brush or vines, the operator raised or tilted the sensors, side to side, to extract them from the tangle. The sensors were also raised or tilted to clear unavoidable obstacles, such as ridges and dead falls. Both of these situations caused the sensors to become misaligned.

6.3 After the data were processed, ASCII data files were output and delivered, and the interactive target analysis began (Figure 1 a). For analysis, the data are viewed in its interpolated form, zoomed in to the pixel level (one magnetometer value for each 10 cm display pixel Figure 1 b). The display range is adjusted for optimum contrast (typically ± 100 gammas) and a choice of gray scale or color. The local background can also be adjusted to normalize data around zero. The operator then scrolls through the data and analyzes each anomaly observed. For this analysis, each anomaly 10 gammas above or below the local background were analyzed. Interactively, an area of interest (AOI) around the anomaly is selected. The uninterpolated data inside the selected AOI are analyzed for peak positive and negative values (Figure 1c). These points are identified with marks on the display. If the peaks do not match what the operator observes in the data (typical in cluttered environments), the operator reselects the AOI to better contain the data to be analyzed. With a good AOI, the data are recursively matched to a magnetic dipole model that is seeded with the "full width at half maximum" estimate derived from the positive and negative peaks in the AOI. The results of the model match are the anomaly location, depth estimate (meters below ground), and size estimate (Figure 1d). The size estimates (small (s), medium (m), or large (l)) are based on the magnetic moment derived from the model match. Magnetic moments from 0 to 5 amp-meters squared are categorized small. Magnetic moments between 5 and 10 are categorized medium. Magnetic moments greater than 10 are categorized as large. The results of the model match are displayed to the operator. If the analysis results match the data, the operator logs the anomaly to a target file with an optional comment (e.g. Large surface object, near Tokyo Road). If the anomaly repeatedly fails to match the dipole model (cluttered area, insufficient data sampled, "bad magnetometer value" included in AOI), the operator may pinpoint the anomaly. Placing the cursor over the anomaly, and clicking the mouse does this. The cursor location is determined and displayed over the data with no depth estimate (-

999.00 m reported) and a "p" entered in the size column. If the operator is satisfied with the location they may log the target with an optional comment (e.g. "indication of object north of line") or retry the process. Logged targets can be overlaid onto the survey image map (Figure 1 e). This analysis process is continued until all data has been reviewed. Electronic and hard copy target reports are then output and are included as APPENDIX D.

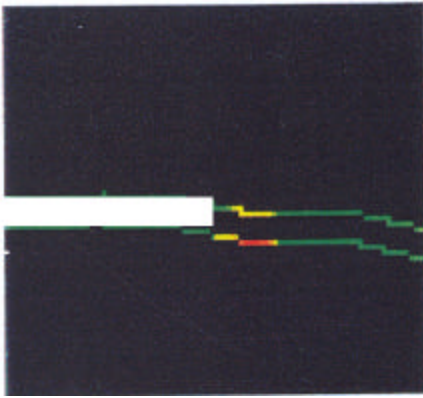


Figure 1a. Preprocessed Data
(Spatially mapped data)

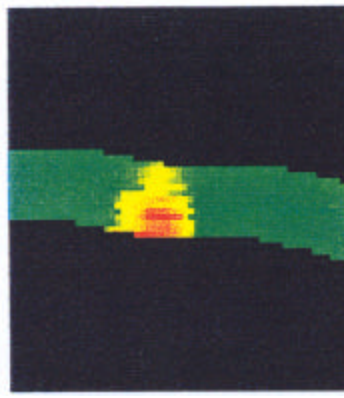


Figure 1b. Interpolated Data
(10 cm gridded data)

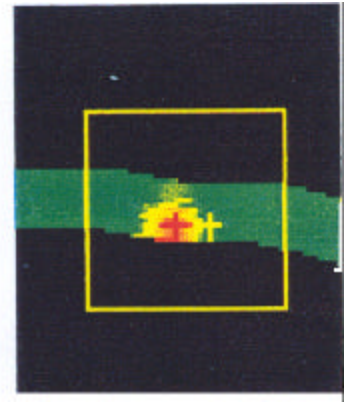


Figure 1c. Analysis AOI
(Peak +/- in AOI)

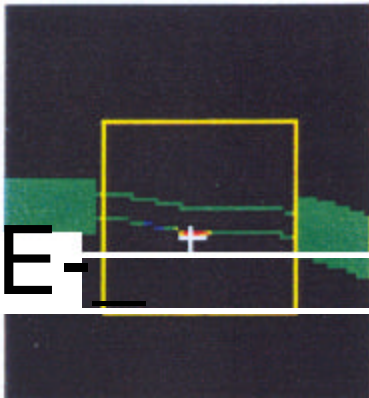


Figure 1 d. Analysis Location
(Analysis uses raw data for magnetic dipole model match)

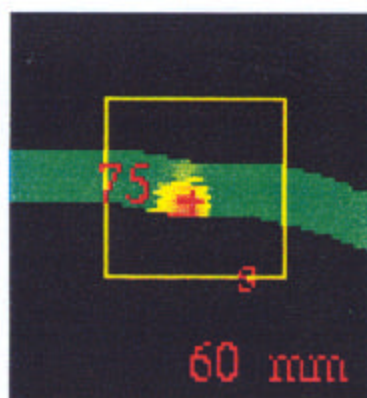


Figure 1 e. Target Overlay
(Overlay includes target number, size, and comment)

Figure 1. Representative geophysical data through GEO-CENTERS' data analysis process (Scale +/- 100 Gammas)

6.4 One of the issues affecting the analysis of this data was the limited area sampled along each survey path. This is always an issue at the edges of any survey where only a portion of an object's signature, outside the area surveyed, is acquired. The pseudo random walk used in this survey left edges along each line. Only a limited number of anomalies had their entire magnetic signature contained in the searched swath and thus analyzed successfully with the magnetic dipole model match. Even the results of some of the model matches are suspect and are commented on (e.g. "looks larger"). Most of the reported targets were pinpointed.

7. 0 Statistical Selection of Representative Targets

7.1 The statement of work (SOW) required the analyzed target report for each site to be randomly downsized to 31.5%. This was done using a random number generator to pick each target from the list. For the 295-acre site, 61 targets were selected for the final target report. The down-selected percentage resulted in 19 randomly selected targets. The additional 5.5-acre site had 28 targets reported that were randomly downsized to 9 targets. These randomly selected targets were then sorted by decreasing Northing and increasing Easting (northwest to southeast) to provide an optimum sequence for relocation. The final target report/dig sheet is included as APPENDIX E.

7.2 Ultimately the COE requested that all identified targets be reacquired. However, because the area investigated was larger than the original site (e.g. the western boundary was extended to the west perimeter road), twenty-nine (29) of the western-most targets were excluded because their locations were outside of the original site boundaries. To bring the total target reacquisition count back to 89, the COE provided twenty-nine (29) additional potential targets to be reacquired and investigated. This final selected target dig-sheet is included as APPENDIX F. All COE selected targets are identified in the comment column as "Corps selected target".

8.0 Anomaly Reacquisition and Marking Results

8.1 Anomaly (target) reacquisition was coordinated with a target investigation and disposal contractor. To meet the disposal contractor's schedule, GEO-CENTERS' reacquisition team mobilized on Friday 7 May 1999. Target reacquisition began on 8 May 1999, two days ahead of the investigation and disposal team. The reasons for this lead-time were to:

1. Insure adequate safe separation (200 foot exclusion zone during any digging operation) distance between the reacquisition team and the target being investigated, and
2. To insure that all 89 targets were reacquired prior to the end of the investigation and disposal contractor's four-day schedule.

8.2 Anomaly reacquisition times were scheduled with time windows of peak GPS satellite coverage (elevation mask of 25 degrees above horizon and a minimum of five satellites in view). For 8 May, these times (in local time) were as follows:

1st time window: 08:00 - 11:00

2nd time window: 12:45 - 18:45

3rd time window: 19:00 - 19:30

*Note: a minimum of 5 Satellite Vehicles (SVs) were required for each survey window

8.3 The reacquisition process included loading the selected target locations into the rover DGPS receiver. The same DGPS receiver was used for target reacquisition as was used for the geophysical investigation. This unit was a Trimble Model Pro XR. The built-in U. S. Coast Guard differential correction radio provided the realtime differential corrections (no local base station was required). The receiver was operated in the "code only" mode to maximize its ability to maintain satellite lock in the woods. [This receiver is capable of locking and tracking the GPS L1 carrier phase for greater location accuracy at the expense of lower satellite lock capability in wooded areas].

8.4 The rover DGPS receiver provided relocation guidance to each target. The relocated position was marked with a temporary flag. The area around the flag was investigated with a handheld magnetic gradiometer (Model GA 72cd Schonstedt). If the target was verified, the marking flag was labeled with the target number. If the verified location was different than the DGPS location, the flag was moved to the verified location and the offset and direction were logged on the dig-sheet (see APPENDIX G). If the target was not verified, the flag was left in the original location and the dig-sheet was updated to report NV (not verified). The ground around the final marked location was painted with high visibility paint. Lengths of surveyor's tape were hung from nearby trees to help the investigation and disposal team find the marked targets. For hard to find targets, flags were placed on the perimeter roads to indicate entrance points and were labeled with target number(s), heading, and range.

8.5 Reacquisition began in the additional 5.5 acre site, as recommended by the investigation and disposal team. On 8 May, targets 1 through 25 were reacquired and verified. Targets # 1 and #3 could not be verified. On 9 May 1999, the additional 5.5 acre site target reacquisition was completed. Target #38 was not verified. Target reacquisition then began in the 295-acre site's northeast corner. Sixteen (16) targets were reacquired and marked before the end of the day.

8.6 On 10 May, GEO-CENTERS began reacquiring targets in the southern portion of the 295-acre site. This allowed the OE subcontractor to investigate and dispose of the targets in the additional 5.5 acre site, while the GEO-CENTERS reacquisition team maintained the safe separation (1200-foot exclusion zone). The anomaly reacquisition team successfully reacquired and marked 18 targets in the first nav window. Then the investigation and disposal team moved south and GEO-CENTERS continued marking targets north. Good satellite coverage, throughout most of the day, allowed GEO-CENTERS to finish marking all except 3 targets in the very center of the 295-acre site.

8.7 Target reacquisition was completed on 11 May. The GEO-CENTERS team remained onsite the full day to insure that all targets could be found. The team demobilized on 12 May. The investigation and disposal team completed the ground truth (what was found at each reacquired target location) portion of the final dig-sheet included in APPENDIX G.

9. D Why Certain Targets Were Not Verified.

9.1 There are several reasons why certain targets were not verified during the reacquisition task. These include:

1. Differences in sensitivity between the total field magnetometers used for the geophysical investigation and the handheld magnetic gradiometer used for verification. Note that target # 1 in the additional 5.5 acre site was not verified, but a carriage bolt was found by investigating the location anyway.
2. Because the sites are not secure areas, it is possible that some targets were moved between the time of the survey and reacquisition. This is not a very likely reason for targets deep inside an area, but may apply to targets along the access roads where higher pedestrian traffic is expected.
3. During the data preprocessing, the survey navigation data are corrected (described in the data processing and analysis section above). These corrections may have been great enough to preclude accurate reacquisition. A detailed analysis of this could be undertaken, but is currently outside of the scope of this draft final report. It is noted that thirteen (13), or 65%, of the twenty "not verified" targets were included in the "Corps selected targets". Seven (7), or 35%, of the "not verified" targets were part of GEO-CENTERS' original target list, one of which was identified. This resulted in a total of 19 "false positive" anomalies or (19/89) 21.3%. This is above the desired goal of no more than 15% "false positives". Evaluating just GEO-CENTERS' targets provides a "false positive" result of (6/60) 10%.

10.0 Why Some Offsets Were So Large:

10.1 The offset distances (in meters) reported in the dig-sheet of APPENDIX G range from zero (0) meters up to a maximum of ten (10) meters. There are several explanations for this wide range of relocation offsets:

1. As explained in the data processing and analysis section above, only two (2) lines of magnetometer data, 0.5 meters apart, were acquired along each survey path. Most of the detected targets were either left or right of the survey path and as such, presented only a portion of their magnetic signature for analysis. This presented a complication to GEO-CENTERS' traditional target analysis by matching survey data to a magnetic dipole model. Note that thirty (30) of GEO-CENTERS' sixty (60) targets were identified by the analyst "pin pointing" the target location. Note that all offsets greater than 3.2 meters were associated with pinpointed targets. This problem could be minimized by deploying a wider sensor array or by surveying adjacent lines, both difficult in wooded areas. The addition of a third sensor in the middle of the array (e.g. three sensors on 0.25 meter centers) may provide a more robust data set for time series based data analysis.

GEO-CENTERS, INS.

2. The navigation corrections applied during the preprocessing step also accounts for some of this variance.

Note 1: As the survey progressed (e.g. by the time the Additional 5.5 Acre Site was surveyed), the reacquisition offsets were much lower. This was due to better use of the satellite planning software (we learned to increase the elevation mask to better optimize the survey time windows), and a less aggressive navigation correction procedure was used.

Note 2: Accuracy would be expected to improve by conducting the geophysical investigation and anomaly reacquisition during periods of little or no leaf canopy.

3. A third, and less attractive, explanation is that the high offset targets -may better have been reported as "not verified". By extending the handheld magnetic gradiometer verification search to such wide circles, the verified anomaly may in fact represent an anomaly that was not detected during the survey and may simply be a different nearby object.

IL 0 Ground Truth Evaluations:

11.1 The objects reported found at the different target locations largely agree with the STOLS® analysis size estimate and the analyst's comments. The only apparent discrepancy is a large target (#34) in the Additional 5.5 Acre Site. The comment for this target indicates that the anomaly was spatially large enough to be that of a culvert under the road/lane. The ground truth for this target reports that a "Small Metal Nugget" was found. The very next ground truth report (for target #35, which has no observable signature) is a "Double Strand Barbed Wire" which better represents the target #34 magnetic signature.

11.2 All of the Corps Selected Targets accurately overlaid onto the survey data. From the image maps, it was not clear that most of these picks represented an obvious anomaly. The double targets #95 and #96, representing the signature of the "OE Rocket Motor" are observable in the image data as two negative anomalies. The local contrast needed to be adjusted to observe these signatures.

12.0 Issues and Recommendations

12.1 The use of satellite planning software to plan optimum survey times greatly helped the survey and reacquisition accuracy.

12.2 Use of available U.S. Coast Guard Differential corrections saved the survey (in a time sense) and greatly eased the logistics by eliminating the need for a local base navigation station and the associated radio link to the survey operator.

12.3 Using an all terrain vehicle or brush clearance team to proceed the survey would minimize the misaligned sensor problem. This has several potential benefits including 1) fewer instances of sensor misalignment, 2) a temporary physical record of traverse path, 3) a potential method to pre-plan sampling area (e.g. instrument clearance vehicle or team with rover GPS).

12.4 Magnetic dipole model matching with partial signature data needs to be evaluated further.

12.5 Reacquisition accuracy varied as follows:

12.5.1 For all 89 targets:

	Original Site:	Additional 5.5 Acre Site:	Combined Sites:
0 meter offset:	8/55 = 14.5%	11/34 = 32.4%	19/89 = 21.3%
< 1 meter offset:	11/55 = 20%	17/34 = 50%	28/89 = 31.5%
< 1.1 meter offset:	20/55 = 36.4%	24/34 = 70.6%	44/89 = 49.4%

12.5.2 For GEO-CENTERS' identified targets:

	Original Site:	Additional 5.5 Acre Site:	Combined Sites:
0 meter offset:	6/32 = 18.8%	11/28 = 39.3%	17/60 = 28.3%
< 1 meter offset:	9/32 = 28.1%	16/28 = 57.1%	25/60 = 41.7%
< 1.1 meter offset:	18/32 = 56.3%	22/28 = 78.6%	40/60 = 66.7%

12.5.3 Future projects that include targets selected by multiple organizations should include a final target review task. This would help minimize the number of "false positives".

12.6 Positioning and reacquisition performance should improve during seasons without leaf canopy.

12.7 This area sampling method is valid for open areas as well.

APPENDIX A
CONTROL MONUMENT DATA SHEETS



Ps Spencer Lane . SAM Antonia, Texas 78201 . 210-736-3188

CONTROL MONUMENT DATA SHEET

CITY, COUNTY AND STATE		NAME OF STATION		MONUMENT TYPE	
JPG, JEFFERSON INDIANA		.LPG 11 1998		BRASS DISK IN CONCRETE	
NORTH (1'): 391237.1865 m			LATITUDE: 38'48'02.5868" N		
EAST (X): 111416.4814 m			LONGITUDE 86'26'35.1311" W		
HORIZ. DATUM:NAO 83 (1997)		ELLIP HEIGHT: GPS DERIVED 222.4 m		DATE ESTABLISHED: AUGUST 1098	
I VERT. DATUM: NIA		STATE PLANE ZONE: INDIANA. EAST		ESTABLISHED 9Y: RAP	
SCALE FACTOR I OR: 0.989971306		CONVERGENCE ANGLE: 0'05'24.56`			
REFERENCED CONTROL: NGS MONUMENTS JPG 1 1997 (PID#AE8506). G.ASGOW RM 2 (PID#JZ1879) MADP (PID#AE8505)					
RECOVERY NOES: FROM THE INTERSECTION OF ENGINEERS ROAD AND TOKYO ROAD PROCEED 46MTR (160'FT) SOUTH ON TOKYO ROAD TO STATION ON RIGHT 7.6MTRS (26'FT) OFF THE CL OF GRAVEL ROAD.					
SKETCH OF I V , W Z V (X		STATION: a		TREE LINE GRAVEL ROAD'S O p ENGINEERS ROAD ·————~— O Y' r BLDG	

No 7 E: ALL DIRECTIONAL DATA IS BASED UN TI- c ABOVE REFERENCED t; I I ATE FLANK ERIC

GEO-CENTERS, ANC.

DDJ . S SON= VC.
CONSULTING ENGINEERS . LAND SURV
 55 SPENCER LANE . SAM ANTONIO, TEXAS 78104-196

CONTROL MONUMENT DATA SHEET

CITY COUNTY, AND STATE

NAME OF STATION

MONUMENT TYPE

JPG, JEFFERSON, INDIANA

JPG 12 1998

BRASS DISK IN CONCRETE

NORT14 (Y):

398801.0991 m LATITUDE:

38°50'18.9753" N

GATE ESTABLISHED: AUGUST

HORIZ. DATUM: NAD 83 11887)

ELLIP HEIGHT:

GPS DERIVED

VERT. DATUM: N/A

STATE PLANE ZONE: INDIANA. EAST ESTABLISHED BY: RAP

SCALE FACTOR: 0.999970842

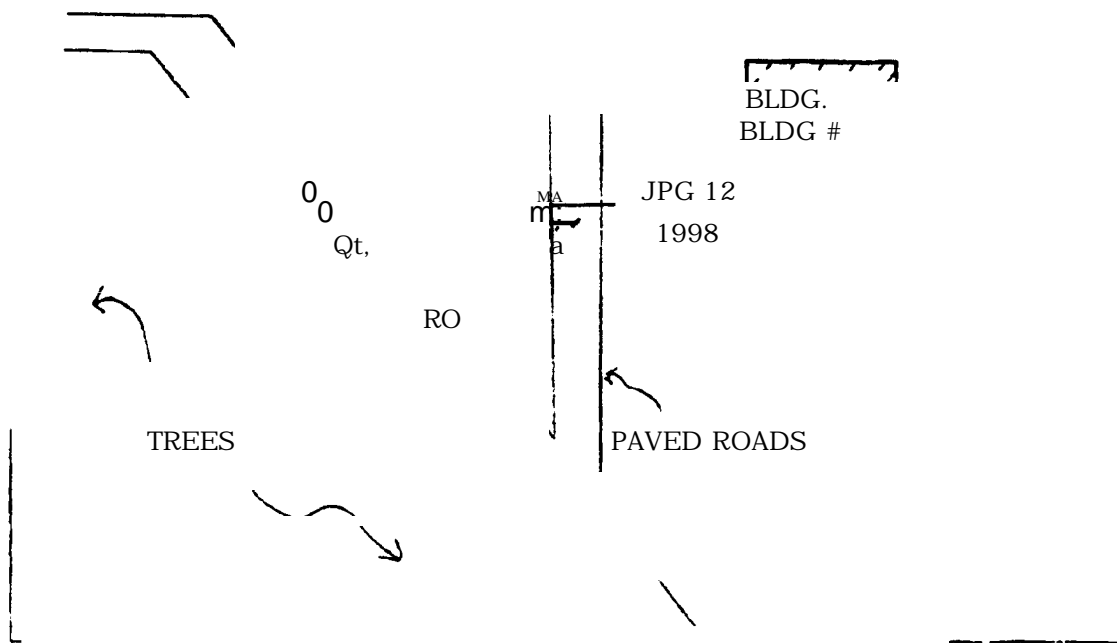
CONVERGENCE ANGLE: 0°07'69.01

REFERENCED CONTROL NGS MONUMENTS: JPG 1 1897 (PID#AE8505) GLASGOW RM. 2 (PID#JZ1879), MADP (PID#AE8505)

RECOVERY NOTE&: FROM THE INTERSECTION OF TOKYO ROAD AND WOODALL ROAD PROCEED WEST TO A (Y) IN THE ROAD. TAKE THE NORTH PAVED ROAD. THE STATION IS ON THE LET 9MTRS (30FT) FROM CL OF PAVED ROAD AND 64MTPS (1210'FT) SOUTH EAST OF PERIMETER FENCE.

SKETCH OF STATION:

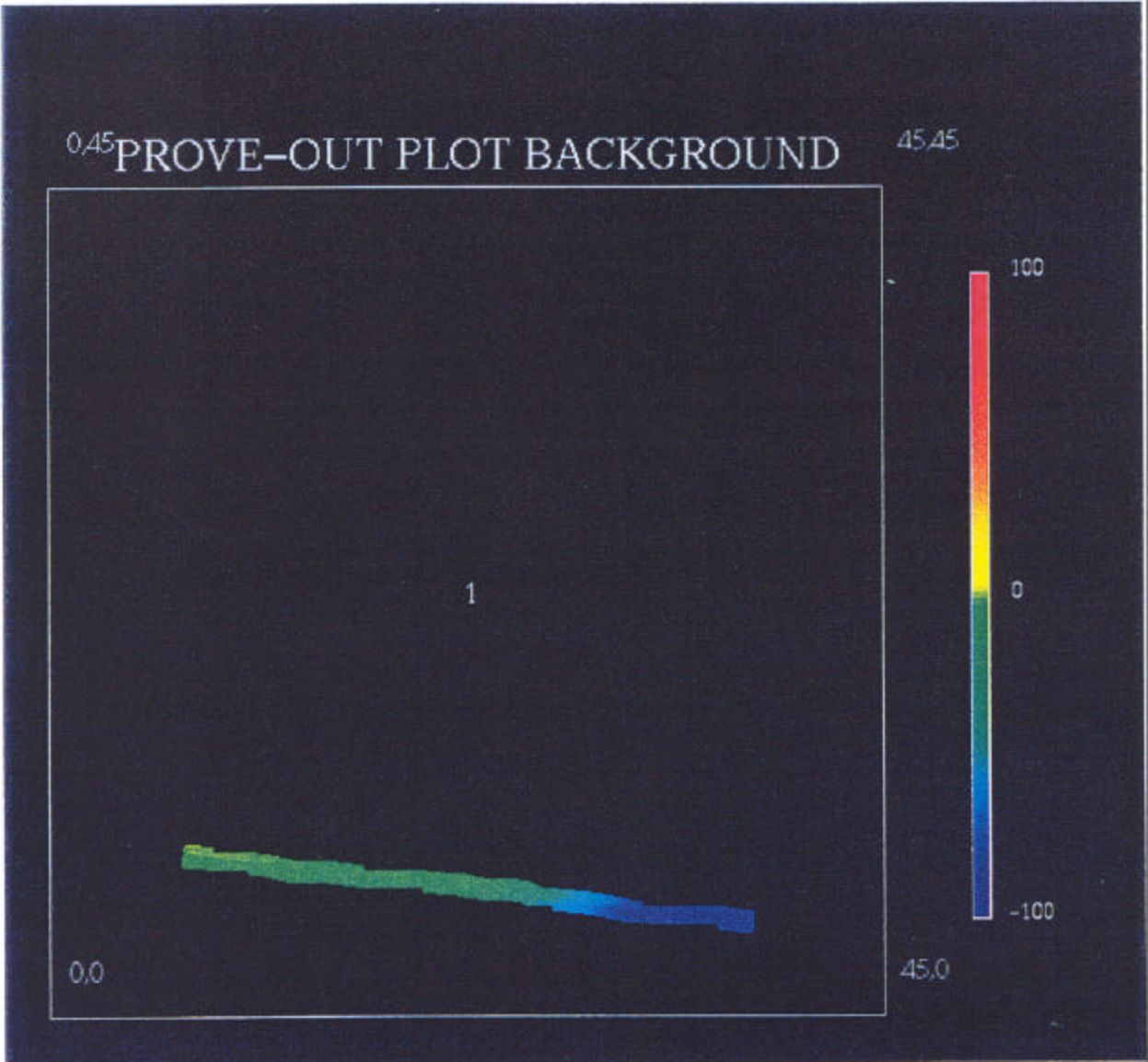
A PERIMETER CHAIN LINK FENCE _

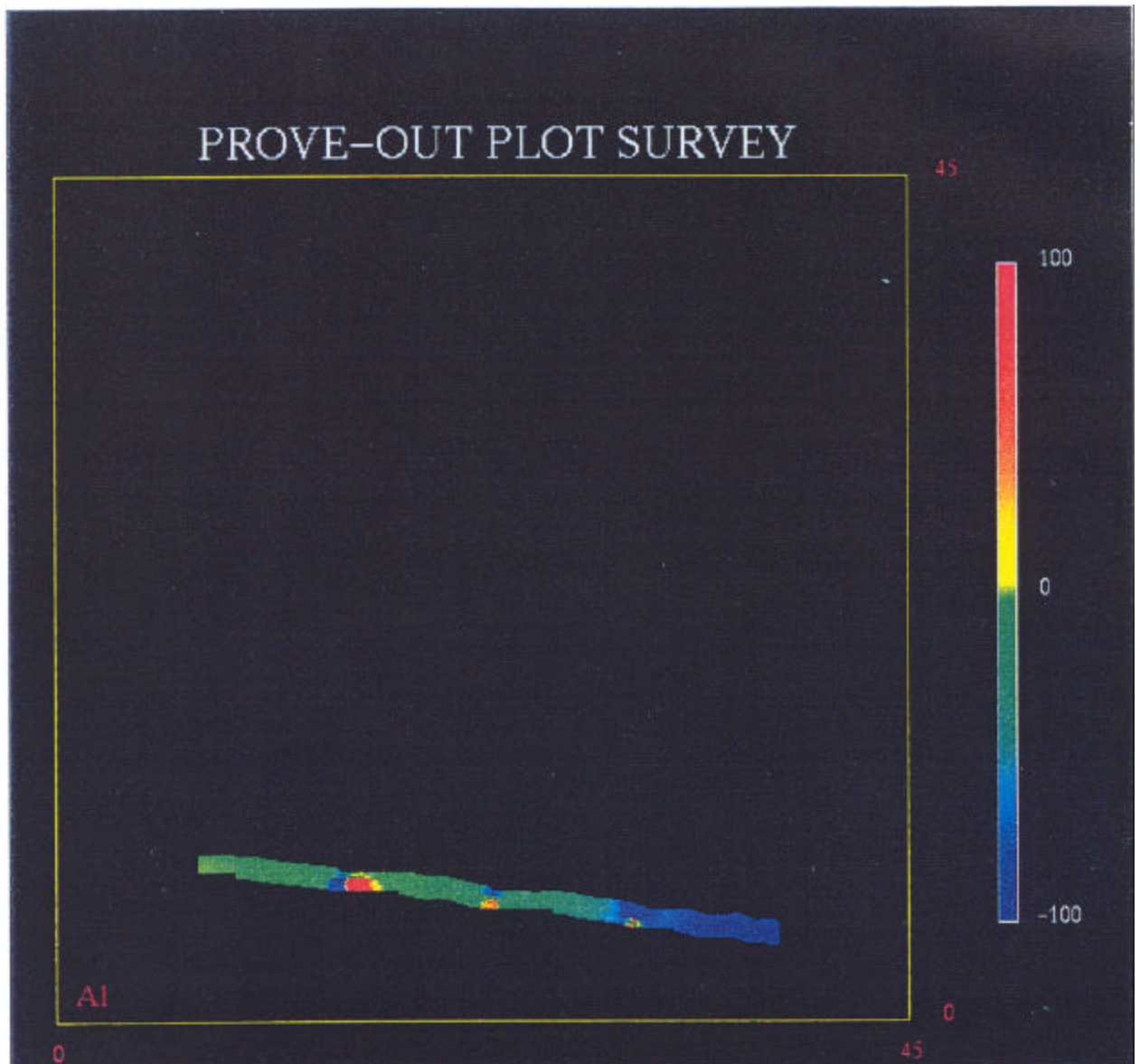


NOTE ALL DIRECTIONAL DATA IS BASED ON THE ABOVE REFERENCE= STATE PLANE UP-D.

APPENDIX B

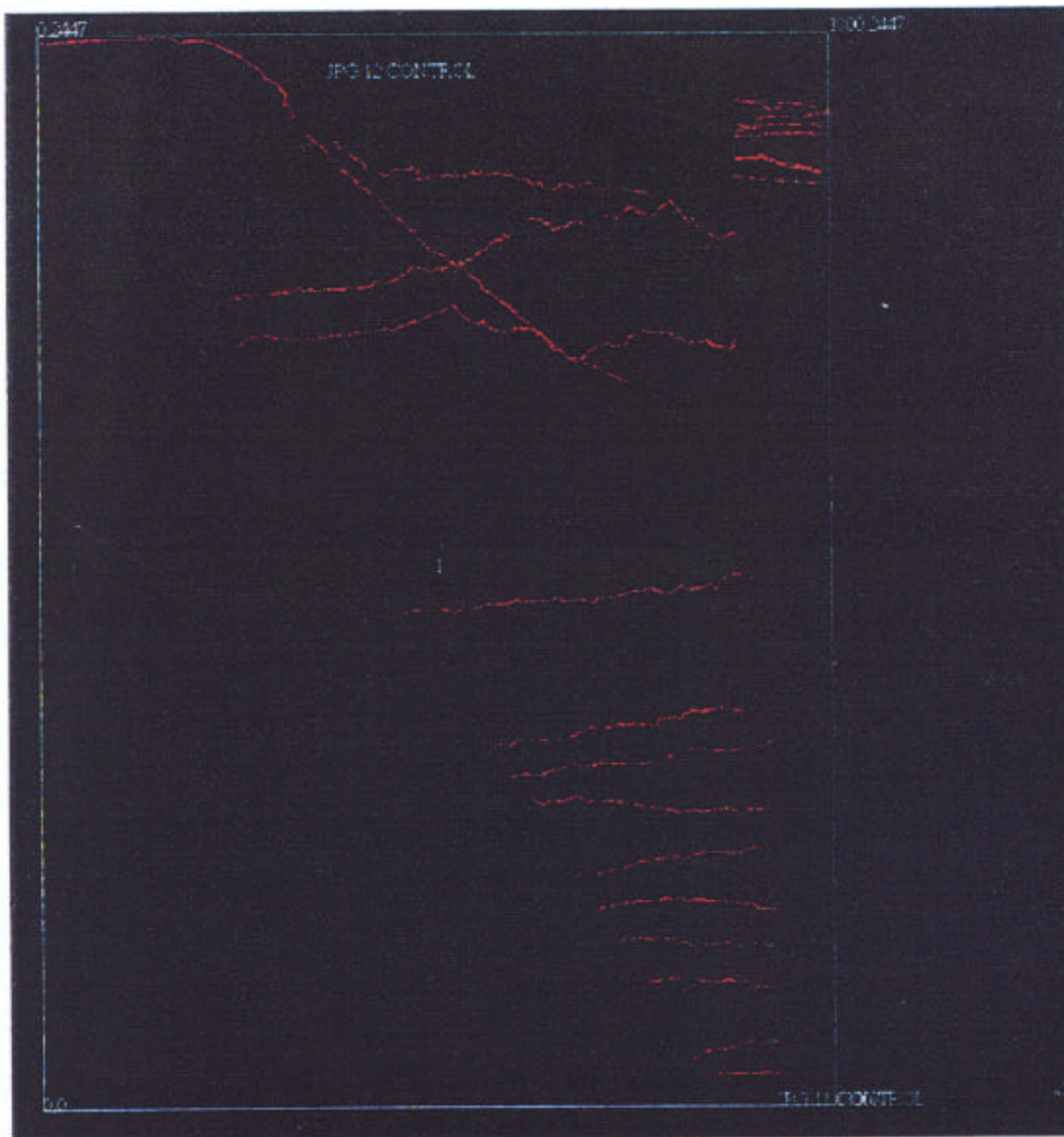
PROVE-OUT BACKGROUND AND TEST DATA IMAGES





APPENDIX C

NAVIGATION TRAVERSE MAP OF THE AREAS SURVEYED



Navigation Traverse Map of the Areas Surveyed



GEO-CENTERS, INC.

APPENDIX D

COMPLETE TARGET REPORT OR DIG SHEET

Estimated target depth is derived from match to magnetic dipole model

Positive depth values are depth below ground in meters Negative depth values indicate a surface or above ground object

Size estimates of small (s), medium (m), large (l), and pinpoint (p) are described in paragraph 6.3 of this report.

Selected Target Report		/ Dig Sheet for JPG 295 Acre Site			
Target #	Easting (m)	Northing (m)	Depth (in)	Size	Comments - Selected Targets
3	117804.57	398688.40	-999.00	p	May be miss-align d magnetometer
4	117809.98	398688.38	3.101	l	Deep
6	117818.20	398688.95	-999.00	P	Larger object south of line
7	117822.21	398689.94	-999.00	P	Larger object north of line
8	117826.22	398689.32	-999.00	P	Indication of object south of line
9	117846.28	398692.65	-999.00	P	Indication of object north of line
10	117848.48	398692.44	-999.00	P	Indication of object south of line
13	117865.33	398694.77	-999.00	P	Indication of object north of line
15	118016.59	398694.22	3.80	L	Across line, analysis locates it south of line
16	118032.93	398697.56	-999.00	P	Small object south of line
17	118040.75	398697.53	-999.00	P	Small object south of line
18	118042.76	398697.52	-999.00	P	Small object south of line
19	118048.37	398697.91	-999.00	P	Small object south of line
20	118059.40	398697.66	-999.00	P	Small object north of line
21	118071.81	398692.42	-999.00	P	Small object north of line
22	118073.00	398689.83	-999.00	P	Larger object south of line
23	118075.40	398688.42	-999.00	P	Small object south of line
24	118096.66	398690.54	-999.00	P	Larger object north of line I
25	118147.16	398686.36	-999.00	P	Object north of line
27	118162.38	398681.52	-999.00	P	Small object south of line
28	118320.41	398561.15	-0.40	S	Small surface object
31	118511.36	398342.43	-999.00	P	Indication of object north of line
35	118888.29	398355.54	2.00	l	Across line
37	119014.93	397985.03	0.90	l	Large object north of line
39	119338.05	397999.63	-999.00	P	Larger, deeper object
40	119336.02	398239.52	0.20	l	Large object, analyzes south of line
41	119104.20	398301.16	-999.00	P	May be miss-aligned magnetometer
42	118989.80	398263.43	-999.00	P	Small object east of line
45	119017.58	398351.18	-999.00	P	Indication of object north of line
46	119081.92	398346.35	-0.40	S	Part of a cluster across line
47	118140.45	398688.49	1.20	S	
48	118134.24	398689.51	-999.00	P	Indication of small object south of line
49	118130.74	398690.21	-999.00	P	Indication of small object south of line
53	118526.27	398391.20	-999.00	P	Indication of small object south of line
54	118416.14	398479.25	-999.00	P	Indication of small object north of line - poor nav.

Selected Target Report		/ Dig Sheet for JPG 295 Acre Site - Continued			
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - Selected Targets
55	118670.34	398070.63	0.50	s	
56	118932.37	396954.21	0.30	s	
58	118958.44	397039.87	0.80	m	
59	118949.92	397038.69	-0.30	s	Small surface object, ma be art of cluster
60	118941.78	397034.13	-999.00	P	Small object north of line
71	119372.09	396407.06	-999.00	P	Small object, ma be art of a cluster
72	119414.08	396404.11	0.20	S	Small object near Tokyo Road
73	119415.58	396403.70	-999.00	P	Small object near target 63, near Tokyo Road
74	119416.25	396530.69	-999.00	P	Small object near Tokyo Road
75	119407.47	396706.81	-999.00	P	Small object near Tokyo Road
76	119064.08	397039.28	-999.00	P	Large surface object
77	119344.18	397158.66	-999.00	P	Indication of surface object near Tokyo Road
78	119337.30	397469.44	-1.20	l	Large surface object south of line, near Tokyo Road
82	119410.38	397088.84	0.40	s	Small object near Tokyo Road
83	119406.97	397086.76	0.00	s	Small object near Tokyo Road
85	119337.87	396721.94	1.00	s	Indication of small object north of line
86	119297.28	396724.58	0.30	s	Indication of small object south of line
87	119416.69	396624.32	0.20	s	Indication of small object south of line
88	119411.99	396626.63	0.90	s	Indication of small object north of line
89	119137.12	397438.63	0.60	s	Very small object

Selected Target Report		/ Dig Sheet for JPG Woods, Additional 5.5 Acre Site			
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - Selected Targets
1	119357.85	398370.51	-999	P	
2	119368.57	398368.78	0.7	S	
3	119454.33	398356.49	-999	P	Larger, deeper object south of line
4	119465.89	398391.29	-0.5	S	Small object on surface
7	119347.37	398409.69	-999	P	Small object on or near lane/road
8	119345.66	398463.00	0.1	S	Small object on or near lane/road
9	119348.17	398463.99	1.4	S	Small object on or near lane/road north of line
10	119383.45	398462.96	0.3	S	
11	119385.25	398461.55	0.3	S	
13	119450.73	398467.41	0.3	S	
14	119506.77	398469.10	0.2	S	Looks larger
16	119554.81	398478.51	0.6	S	Small object north of line
17	119475.66	398488.48	-999	P	Small object north of line
18	119354.23	398476.74	-999	P	Small object north of line
20	119387.66	398489.70	0.2	S	
21	119414.08	398505.58	-999	P	Small object south of line
22	119462.30	398505.90	-999	P	Small object south of line
23	119477.34	398507.55	-999	P	Small object south of line
25	119482.35	398508.43	-999	P	Small object north of line
26	119532.48	398511.84	-999	P	Small object north of line
27	119532.68	398511.14	-999	P	Small object south of line
28	119528.43	398527.52	-999	P	Small object north of line
29	119507.59	398529.59	0.3	S	
30	119505.89	398530.70	-999	P	Small object north of line
31	119435.69	398521.87	-999	P	Small object south of line
32	119400.07	398539.87	-999	P	Potential cluster of objects north of line
33	119351.68	398545.34	0.1	I	Large object near lane/road - culvert?
34	119344.96	398543.56	-999	p	Object in lane/road - Culvert?
35	119538.60	398370.20			Corps selected target
36	119538.90	398370.60			Corps selected target
37	119538.60	398370.20			Corps selected target
38	119538.80	398370.70			Corps selected target
39	119538.60	398370.30			Corps selected target
40	119538.80	398370.70			Corps selected target

APPENDIX E

**STATISTICAL SELECTION (RANDOM SELECTION OF 31.5% OF TARGETS FROM
APPENDIX D) OF REPRESENTATIVE ANOMALIES**

Estimated target depth is derived from match to magnetic dipole model

Positive depth values are depth below ground in meters Negative depth
values indicate a surface or above ground object

Size estimates of small (s), medium (m), large (l), and pinpoint (p) are described in
paragraph 6.3 of this report.



Randomly Selected Target Report / Dig Sheet for JPG 295 Acre Site 31.5% Of 61 Selected Targets)					
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments - Statistically Selected Representative Targets
17	118040.75	398697.53	-999.00	P	Small object south of line
9	117846.28	398692.65	-999.00	P	Indication of object north of line
6	117818.20	398688.95	-999.00	P	Larger object south of line
47	118140.45	398688.49	1.20	s	
23	118075.40	398688.42	-999.00	P	Small object south of line
4	117809.98	398688.38	3.101	1	Deep
27	118162.38	398681.52	-999.00	P	Small object south of line
35	118888.29	398355.54	2.001	1	Across line
45	119017.58	398351.18	999.00	P	Indication of object north of line
41	119104.20	398301.16	-999.00	p	May be miss- aligned magnetometer
78	119337.30	397469.44	-1.20	1	Large surface object south of line, near Tokyo Road
65	118980.06	397413.84	0.10	s	
67	118757.59	397401.37	0.70	s	
77	119344.18	397158.66	-999.00	p	Indication of surface object near Tokyo Road Negative Anomaly Only
82	119410.38	397088.84	0.40	s	Small object near Tokyo Road
61	118855.92	397016.88	-999.00		Small object in line
56	118932.37	396954.21	0.30	s	
75	119407.47	396706.81	-999.00	p	Small object near Tokyo Road

Randomly Selected Target Report / Dig Sheet for JPG Additional 5.5 Acre Site 31.5% Of 28 Selected Targets)					
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments - Statistically Selected Representative Targets
30	119505.89	398530.70	-999	P	Small object north of line
28	119528.43	398527.52	-999	P	Small object north of line
31	119435.69	398521.87	-999	P	Small object south of line
26	119532.48	398511.84	-999	P	Small object north of line
25	119482.35	398508.43	-999	P	Small object north of line
22	119462.30	398505.90	-999	p	Small object south of line
20	119387.66	398489.70	0.2	s	
14	119506.77	398469.10	0.2	s	Looks larger
7	119347.37	398409.69	-999	p	Small object on or near lane/road
2	119368.57	398368.78	0.7	s	
39	119538.60	398370.30			Corps selected target

APPENDIX F

FINAL CORPS SELECTED TARGET DIG-SHEET

Estimated target depth is derived from match to magnetic dipole model
Positive depth values are depth below ground in meters Negative depth
values indicate a surface or above ground object

Size estimates of small (s), medium (m), large (l), and pinpoint (p) are described in
paragraph 6.3 of this report.

Target Report / Dig Sheet for JPG 295 Acre Woods Site					—
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments - All Targets
28	118320.41	398561.15	-0.40	s	Small surface object
31	118511.36	398342.43	-999.00	p	Indication of object north of line
35	118888.29	398355.54	2.00	1	Across line
37	119014.93	397985.03	0.90	1	Large object north of line
39	119338.05	397999.63	-999.00	P	Larger, deeper object
40	119336.02	398239.52	0.20	1	Large object, analyzes south of line
41	119104.20	398301.16	-999.00	P	May be miss- aligned magnetometer
42	118989.80	398263.43	-999.00	P	Small object east of line
45	119017.58	398351.18	-999.00	P	Indication of object north of line
46	119081.92	398346.35	-0.40	S	Part of a cluster across line
53	118526.27	398391.20	-999.00	P	Indication of small object south of line
54	118416.14	398479.25	-999.00	P	Indication of small object north of line - poor nav. Area
55	118670.34	398070.63	0.50	S	
56	118932.37	396954.21	0.30	S	Across line
58	118958.44	397039.87	0.80	M	Large positive anomaly across line
59	118949.92	397038.69	-0.30	S	Small surface object, may be part of cluster
60	118941.78	397034.13	-999.00	P	Small object north of line
71	119372.09	396407.06	-999.00	P	Small object, may be part of a cluster
72	119414.08	396404.11	0.20	S	Small object near Tokyo Road
73	119415.58	396403.70	-999.00	P	Small object near Tokyo Road
74	119416.25	396530.69	-999.00	P	Small object across line, near Tokyo Road
75	119407.47	396706.81	-999.00	P	Small object near Tokyo Road
76	119064.08	397039.28	-999.00	P	Large surface object, negative anomaly only
77	119344.18	397158.66	-999.00	P	Indication of surface object near Tokyo Road, negative anomaly only
78	119337.30	397469.44	-1.20	1	Large surface object south of line, near Tokyo Road
82	119410.38	397088.84	0.40	S	Small object near Tokyo Road
83	119406.97	397086.76	0.00	S	Small object near Tokyo Road
85	119337.87	396721.94	1.00	S	Indication of small object north of line
86	119297.28	396724.58	0.30	S	Indication of small object south of line
87	119416.69	396624.32	0.20	S	Indication of small object south of line near Tokyo Road
88	119411.99	396626.63	0.90	S	Indication of small object north of line near Tokyo Road
89	119137.12	397438.63	0.60	S	Very small object

Target Report / Dig Sheet for JPG 295 Acre Woods Site Continued					
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments - All Targets
90	118758.21	397401.12			Corps selected target
91	119332.23	397981.91			Corps selected target
92	118815.02	398021.49			Corps selected target
93	118879.89	398037.39			Corps selected target
94	118698.77	398180.45			Corps selected target
95	118735.63	398185.73			Corps selected target
96	119243.60	398277.08			Corps selected target
97	119242.93	398277.38			Corps selected target
98	119150.99	398328.96			Corps selected target
99	118934.55	398346.28			Corps selected target
100	118707.85	398373.36			Corps selected target
101	118703.62	398375.65			Corps selected target
102	118680.19	398375.98			Corps selected target
103	118774.31	398379.45			Corps selected target
104	118835.63	398379.78			Corps selected target
105	118606.79	398396.37			Corps selected target
106	118505.11	398403.23			Corps selected target
107	118488.33	398414.24			Corps selected target
108	118458.15	398437.65			Corps selected target
109	118435.04	398459.69			Corps selected target
110	118369.69	398478.78			Corps selected target
111	118320.58	398551.80			Corps selected target
112	118282.69	398600.82			Corps selected target

Target Report / Dig Sheet for JPG Woods, Additional 5.5 Acre Site					
Target #	Easting (m)	Northing (m)	Depth (m)	Size	Comments - All Targets
1	119357.85	398370.51	-999	p	
2	119368.57	398368.78	0.7	s	
3	119454.33	398356.49	-999	p	Larger, deeper object south of line
4	119465.89	398391.29	-0.5	s	Small object on surface
7	119347.37	398409.69	-999	p	Small object on or near lane/road
8	119345.66	398463.00	0.1	s	Small object on or near lane/road
9	119348.17	398463.99	1.4	s	Small object on or near lane/road north of line
10	119383.45	398462.96	0.3	s	
11	119385.25	398461.55	0.3	s	
13	119450.73	398467.41	0.3	s	
14	119506.77	398469.10	0.2	s	Looks larger
16	119554.81	398478.51	0.6	s	Small object north of line
17	119475.66	398488.48	-999	p	Small object north of line
18	119354.23	398476.74	-999	p	Small object north of line
20	119387.66	398489.70	0.2	s	
21	119414.08	398505.58	-999	p	Small object south of line
22	119462.30	398505.90	-999	p	Small object south of line
23	119477.34	398507.55	-999	p	Small object south of line
25	119482.35	398508.43	-999	p	Small object north of line
26	119532.48	398511.84	-999	p	Small object north of line
27	119532.68	398511.14	-999	p	Small object south of line
28	119528.43	398527.52	-999	p	Small object north of line
29	119507.59	398529.59	0.3	s	
30	119505.89	398530.70	-999	p	Small object north of line
31	119435.69	398521.87	-999	p	Small object south of line
32	119400.07	398539.87	-999	p	Potential cluster of objects north of line
33	119351.68	398545.34	0.1	l	Large object near lane/road
34	119344.96	398543.56	-999	p	Object in lane/road - Culvert?
35	119346.62	398371.51			Corps selected target
36	119452.07	398399.84			Corps selected target
37	119434.43	398406.61			Corps selected target
38	119408.54	398417.72			Corps selected target
39	119525.52	398487.84			Corps selected target
40	119409.09	398488.88			Corps selected target

APPENDIX G

FINAL DIG-SHEET

With

OFFSET and GROUND TRUTH RESULTS

(Note that actual depth ground truth results were not provided to GEO-CENTERS, INC.)

Estimated target depth is derived from match to magnetic dipole model
Positive depth values are depth below ground in meters Negative depth
values indicate a surface or above ground object

Size estimates of small (s), medium (m), large (l), and pinpoint (p) are described in
paragraph 6.3 of this report.



GEO-CENTERS, INC.,

Target Report / Dig Sheet for JPG 295 Acre Woods Site							
Target #	Easting (m)	Northing (m)	Depth	Size	Comments - All Selected Targets	Offset (m)	Ground Truth
28	118320.41	398561.15	-0.40	S	Small surface object	NV	No Contact
31	118511.36	398342.43	-999.00	P	Indication of object north of line	0	Horse Shoe
35	118888.29	398355.54	2.001	1	Across line	1 N	1/2" Braided wire cable
37	119014.93	397985.03	0.901	1	Large object north of line	0	(1) 55 gallon drum very rusty
39	119338.05	397999.63	-999.00	P	Larger, deeper object	1 SW	Barb wire
40	119336.02	398239.52	0.20	1	Large object, analyzes south of line	1 E	Barb Wire
41	119104.20	398301.16	-999.00	P	May be miss- aligned magnetometer	NV	No Contact
42	118989.80	398263.43	-999.00	P	Small object east of line	2.5 S	Horse Shoe
45	119017.58	398351.18	-999.00	P	Indication of object north of line	5 SE	Steel Plate
46	119081.92	398346.35	-0.40	S	Part of a cluster across line	3.2 N	Conduit 1/2"
53	118526.27	398391.20	-999.00	P	Indication of small object south of line	10 N	1/2" Bar
54	118416.14	398479.25	-999.00	p	Indication of small object north of line - poor nav. Area	5 NW	Wire
55	118670.34	398070.63	0.50	S		1.5 SE	Bolt
56	118932.37	396954.21	0.30	S	Across line	2 SE	Double Strand Barb Wire
58	118958.44	397039.87	0.80	M	Large positive anomaly across line	.75 W	BarbWire
59	118949.92	397038.69	-0.30	S	Small surface object, may be art of cluster	1 SW	Grounding Rod
60	118941.78	397034.13	-999.00	P	Small object north of line	0	Banding
71	119372.09	396407.06	-999.00	P	Small object, may be part of a cluster	NV	No Contact
72	119414.08	396404.11	0.20	S	object near Tokyo (Small Road	.5 S	BarbWire

Target Report / Dig Sheet for JPG 295 Acre Woods Site Continued							
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - All Selected Tar Targets	Offset (m)	Ground Truth
73	119415.58	396403.70	-999.00	p	Small object near Tokyo Road	1 W	Wire
74	119416.25	396530.69	-999.00	p	Small object across line, near Tokyo Road, negative anomaly only	2 W	Multiple Barb Wire Pieces
75	119407.47	396706.81	-999.00	p	Small object near Tokyo Road	1 E	60 mm Fuzed Mortar
76	119064.08	397039.28	-999.00	p .	Large surface object, negative anomaly only	0	(4) 55 Gallon Drums Very R
77	119344.18	397158.66	-999.00	p	Indication of surface object near Tokyo Road, negative anomaly only	.15 N	Barb Wire
78	119337.30	397469.44	-1.20	l	Large surface object south of line, near Tokyo Road	1 N	Wire Fence
82	119410.38	397088.84	0.40	s	Small object near Tokyo Road	1 W	Barb Wire
83	119406.97	397086.76	0.00	s	Small object near Tokyo Road	1 SW	Barb Wire
85	119337.87	396721.94	1.00	s	Indication of small object north of line	1.5 E	Horse Shoe
86	119297.28	396724.58	0.30	s	Indication of small object south of line	NV	No Contact
87	119416.69	396624.32	0.20	s	Indication of small object south of line near Tokyo Road	0	Banding 1"
88	119411.99	396626.63	0.90	s	Indication of small object north of line near Tokyo Road	0	Nail/Wire
89	119137.12	397438.63	0.60	s	Very small object	NV	No Contact
90	118758.21	397401.12			Corps selected target	2.5 NE	Barb Wire
91	119332.23	397981.91			Corps selected target	4 W	Shot Gun Shell Casing
92	118815.02	398021.49			Corps selected target	6 E	Barb Wire
93	118879.89	398037.39			Corps selected target	NV	No Contact
94	118698.77	398180.45			Corps selected target	4.5 N	Rock Magnetic
95	118735.63	398185.73			Corps selected target	4 N	Wire
96	119243.60	398277.08			Corps selected target	0	OE Rocket Motor

Target Report / Dig Sheet for JPG 295 Acre Woods Site Continued							
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - All Selected Targets	Offset (M)	Ground Truth
97	119242.93	398277.38			Corps selected target	0	Same As 96
98	119150.99	398328.96			Corps selected target	NV	No Contact
99	118934.55	398346.28			Corps selected target	NV	No Contact
100	118707.85	398373.36			Corps selected target	NV	No Contact
101	118703.62	398375.65			Corps selected target	NV	No Contact
102	118680.19	398375.98			Corps selected target	NV	No Contact
103	118774.31	398379.45			Corps selected target	5.5 E	Metal Nugget
104	118835.63	398379.78			Corps selected target	NV	No Contact
105	118606.79	398396.37			Corps selected target	NV	No Contact
106	118505.11	398403.23			Corps selected target	NV	No Contact
107	118488.33	398414.24			Corps selected target	3.5 N	Wiper Blade (Trico)
108	118458.15	398437.65			Corps selected target	4 NE	Oil Filter
109	118435.04	398459.69			Corps selected target	NV	No Contact
110	118369.69	398478.78			Corps selected target	NV	No Contact
111	118320.58	398551.80			Corps selected target	4 E	Barb Wire
112	118282.69	398600.82			Corps selected target	NV	No Contact

Target Report / Dig Sheet for JPG Woods, Additional 5.5 Acre Site							
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - All Targets	Offset (M)	Ground Truth
1	119357.85	398370.51	-999	p		NV	Carriage Bolt
2	119368.57	398368.78	0.7	s		1 NW	Double Strand Barb Wire
3	119454.33	398356.49	-999	p	Larger, deeper object south of line	NV	No Contact
4	119465.89	398391.29	-0.5	s	Small object on surface	1.5 NE	Small Metal Nugget
7	119347.37	398409.69	-999	p	Small object on or near lane/road	0	Multiple Strand Barb Wire
8	119345.66	398463.00	0.1	s	Small object on or near lane/road	0	Multiple Strand Barb Wire
9	119348.17	398463.99	1.4	s	Small object on or near lane/road north of line	3 S	Multiple Strand Barb Wire
10	119383.45	398462.96	0.3	s		0	Small Metal Nugget
11	119385.25	398461.55	0.3	s		1 E	Small Metal Nugget
13	119450.73	398467.41	0.3	s		0	Small Metal Nugget
14	119506.77	398469.10	0.2	s	Looks larger	0	Metal Implement
16	119554.81	398478.51	0.6	s	Small object north of line	0	Small Metal Nugget
17	119475.66	398488.48	-999	p	Small object north of line	1 NW	Nugget
18	119354.23	398476.74	-999	p	Small object north of line	2 E	Small Metal Nugget
20	119387.66	398489.70	0.2	s		.75 NE	(2) Small Metal Nugget
21	119414.08	398505.58	-999	p	Small object south of line	.25 S	Small Metal Nugget
22	119462.30	398505.90	-999	p	Small object south of line	0	Small Metal Nugget
23	119477.34	398507.55	-999	p	Small object south of line	.5 W	Small Metal Nugget
25	119482.35	398508.43	-999	p	Small object north of line	.25 NW	Metal Nugget
26	119532.48	398511.84	-999	p	Small object north of line	0	Small Metal Nugget I
27	119532.68	398511.14	-999	p	Small object south of line	0	Small Metal Nugget
28	119528.43	398527.52	-999	p	Small object north of line	0.5 E	Small Metal Nugget
29	119507.59	398529.59	0.3	s		1 S	Small Metal Nugget
30	119505.89	398530.70	-999	p	Small object north of line	1 N	Small Metal Nugget
31	119435.69	398521.87	-999	p	Small object south of line	1 S	Small Metal Nugget
32	119400.07	398539.87	-999	p	Potential cluster of objects north of line	0	Small Metal Nugget
33	119351.68	398545.34	0.1	l	Large object near lane/road	1.75 NE	1" Cable w/Bolt
34	119344.96	398543.56	-999	p	Object in lane/road - Culvert?	0	Small Metal Nugget

Target Report / Dig Sheet for JPG Woods, Additional 5.5 Acre Site							
Target #	Easting (m)	Northing (m)	Depth m	Size	Comments - All Targets	Offset (M)	Ground Truth
35	119346.62	398371.51			Corps selected target	2 S	Double Strand Barb Wire
36	119452.07	398399.84			Corps selected target	1 SE	Small Nugget
37	119434.43	398406.61			Corps selected target	2 N	Small Nugget
38	119408.54	398417.72			Corps selected target	NV	No Contact
39	119525.52	398487.84			Corps selected target	.75 SW	Small Nugget
40	119409.09	398488.88			Corps selected target	1.25 S	Small Metal Nugget


GEO-CENTERS, INC.